Here I will create an extensive outline so that people who are squeamish about dissection can gain as many insights as possible from Robert Becker's The Body Electric. This uncompromising exploration of regeneration, bioelectric phenomena, and the hidden dangers of electromagnetic fields (EMFs) was published in 1985. It is wild how much Becker's work still points to research avenues abandoned and risks unaddressed even still forty years later. Here I present a summary of the book and hopefully more intelligent people than myself can help point me in the direction of more updated research and understanding of this issue.

Chapter 1: Hydra's Heads and Medusa's Blood

Robert Becker had a remarkable career as an orthopedic surgeon, and often considered the origins of medicine and how the modern stainless-steel medicine was not so different from folk healing in that it had the same goal: harnessing healing energy. His specific research focus as an orthopedic surgeon was a hope to address nonunion fractures: the type which fail to knit and must be amputated. In his early professional opinion, nonunions failed to knit because they were missing something that initiated and managed normal healing. He posited that some healing might be a vestige of the regeneration process and began studying how that occurred in other animals.

There is an overview of the literature going back to 1712 when regeneration was first analyzed in earnest in invertebrates such as crawfish and crabs which could regrow limbs. In 1741 Trembley discovered "hydra" polyps which baffled the scientific community with the ability to regrow into new individual living creatures from the pieces of an original polyp which was minced. The most complex creature to have the most remarkable regenerative capabilities was the salamander, an animal we could relate to.

Chapter 2: The Embryo at the Wound

Regeneration was set aside during a philosophical battle between mechanism and vitalism. Mechanists believed that the life could be understood in terms of the same physical and chemical laws that governed nonliving matter, and that belief in the spirit was hokum. Vitalists believed that a spirt like energy made living things fundamentally different.

Early biology centered around the debate between vitalism and mechanism. The foundation of vitalism was Socrates' and Plato's idea of supernatural "forms" or "ideas" from which all things developed their individual characteristics. Hippocrates later contemplated an anima as a soul or life force. Mechanism developed from Aristotle's rationalism in which universal principles were only humanity's understanding of reality that is perceived through the senses. This philosophy became the foundation of science through Decartes, even though he too believed in the animating force to give the machine life at the start.

Early experiments on the regeneration of common flatworms drew an analogy with a match flame. The flame could be split by cutting the match, then rejoined by putting the two halves side by side. The Danish biologist Brønsted suggested the essence of life might be a flamelike field. By 1794 Luigi Galvani, an anatomy professor at the University of Bologna, first discovered the current of injury but did not know it at the time.

In the 1830s Matteucci used the newly invented galvanometer to prove that there was an electronic current which emanated from the wound surface. This led to discoveries regarding nerve impulses, which were not quite electric current, but could be measured electrically.

In the 1880s Boveri mapped out cell division, which revealed that chromosomes transmitted heredity and that each one could exchange smaller units of itself with its counterpart from the other parent. This was very poorly received, particularly by a scientist from Columbia University who set

out to disprove Boveri's hypothesis and actually proved it, called it genes, and won the Nobel Prize in 1933.

This same Morgan also studied salamander limb regeneration. He discovered that the new limb was preceded by a mass of cells that resembled an embryo in an egg. Previously it was thought that differentiation of cells happened only during immaturity, and that a mature cell could never dedifferentiate. But in the adult salamander, this embryo at the wound called a blastema was able to differentiate into the necessary specialized cells to rebuild the limb.

These experiments were run by hundreds, with the same results. Later on in the 1950s in Harvard Medical School, Singer was able to further these experiments by also considering a type of frog which also is known to regenerate. Singer found that the frogs which could regenerate had much bigger nerves than nonregenerative frogs. This also provided a basic explanation for why regeneration declines with increasing evolutionary complexity as more and more nerve tissue becomes concentrated in the brain.

It was in the late 1950s that Dr. Becker began his work in this field. The puzzle pieces he started with which were established by his predecessors were that the extent of the injury is proportional to regeneration; the amount of nerve is proportional to regeneration; the extent of injury is proportional to the current of injury; and the amount of nerve is proportional to the current of injury. The thesis that he developed was that the current of injury is proportional to regeneration.

Becker's identification of the current of injury as the driving force behind the regeneration of salamanders and other creatures was developed from these early studies of nerve damage, electrical currents, and regeneration.

Chapter 3: The Sign of the Miracle

From Becker's very first proposal he received vigorous pushback from the establishment as his thesis went against prevailing dogma. He was able to advocate for himself, and found allies who were able to make sure his proposal was accepted for funding. In his first experiments he found "confirmation better than my wildest dreams!" (page 73.) He was able to prove that the current at the injury site was not due to dying cells, and also that the electric readings showed that opposite polarities indicated a profound difference between the electrical properties of salamanders who could regenerate and frogs who could not. The negative potential is what brough about the all-important blastema in the salamander which allowed for complete regeneration of limbs. He was able to publish his findings in the most prestigious orthopedic journal in the world which led to more connections for future research.

Chapter 4: Life's Potentials

During World War II Burr and Lund put forth similar theories of an electrodynamic field which held the shape of an organism "just as a mold determines the shape of a gelatin dessert" (page 83). Consider this: the molecules in our bodies are constantly changing, and yet we recognize a friend we haven't seen in months even though nothing in them is the same since we last saw them.

Electric current and its effect on nerves began its modern era in 1902 when the French researcher Stephane Leduc rendered animals (including himself) unconscious by passing strong alternating currents through their heads. By the 1930s the techniques of electroshock and electronarcosis began to be questioned in terms of therapeutic value. But there has been extensive research by legitimate therapists in France and the Soviet Union for creating calmative brain-wave frequencies.

Electric fields had first been detected around the heads of animals in 1875 by Caton, but wasn't definitively proven until 1924 when Berger recorded the first EEG which showed rhythmic fluctuations in the voltage, creating brain waves. Modern EEGs use as many as thirty-two channels all over the head, and the frequency of these brain waves correspond with states of consciousness. Delta waves (0.5 to 3 cycles per second) indicate deep sleep; theta waves (4 to 8 cycles per second) indicate trance like states; alpha waves (8 to 14 cycles per second) appear during relaxed wakefulness or meditation; and beta waves (14 to 35 cycles per second), the most uneven forms, accompany all the modulations of our active everyday consciousness.

One fascinating aspect of these experiments on exposed brains of animals and humans was that wherever nerve cells were actively conducting impulses, they also produced a negative potential. Positive potentials appeared from injured cells where there was brain damage, and expanded to uninjured cells and suppressed their ability to send or receive impulses. When a negative voltage was applied to those groups of neurons, their sensitivity increased and they could generate an impulse from weaker stimulus. Externally applied positive voltage depressed nerve function making it harder to produce an impulse. Further experiments indicated that there is a steady direct current along the normal direction of impulse transmission and that the entire nerve cell was electrically polarized; and that this current could only transmit properly if the structures surrounding the nerves were intact. This indicated that it was not an ionic current, but rather that the current was transmitted by the structure outside of the neurons.

A big part of why electricity has not been taken seriously historically is because in earlier times there were only two known ways to conduct current: ionic and metallic. No one ever found wires in animals, so metallic was not a viable consideration. Ionic current works fine across thin membranes, but it would not be possible to sustain an ionic current throughout an entire nerve, even the short ones.

Semiconduction falls halfway between conductors and insulators and are very reliable at conducting their currents over long distances which is why computers, satellites, and more use them. Semiconduction only occurs with orderly molecular structures. The atoms in a crystal are such a structure, with a latticework that allows electrons of atoms to move freely which creates these currents.

Through a series of experiments on worms, fish, amphibians, reptiles, mammals, and humans, Becker proved that in all species these potentials were found in the skin and reflected the arrangement of the nervous system. In humans the three centers of greatest positive potential were the same as in a salamander: the brain, between the shoulder blades, and at the base of the spine. He was also able to create anesthesia using both electricity and magnets, playing on the concept of the electro-magnetic fields within living things, which was just as effective as chemical anesthesia with none of the side effects. Within his first year of research he published three articles in highly regarded journals, including the gold standard *Science* journal. Unfortunately, the established dogma strongly resisted his findings and his papers garnered no citations.

Chapter 5: The Circuit of Awareness

Through further studies on nerves Becker further proved his thesis by identifying the complete circuit within the body. Here an except from page 106 explains:

> The sciatic nerve is what's called a mixed nerve. It has both motor and sensory neurons. Sensory fibers are usually narrower than motor fibers, so it looked as though the front branch was all sensory, the back one all motor. Suppose the DC system also had incoming and outgoing divisions.

> We took readings from other nerves known to be all one type or another. The femoral nerve along the front of the thigh is almost entirely motor in function, and, sure enough, it had an increasing negative potential away from the spine. The spinal nerves that serve the skin of a frog's back are sensory fibers, and they had increasing negative voltages toward the spine.
>
> Now we saw that when you put motor and sensory nerves together into a reflex arc, the current flow formed an unbroken loop. This solved the mystery of what completed the circuit: The current returned through nerves, not some other tissue. Just as Gerard had found in the brain, nerves throughout the body were uniformly polarized, positive at the input fiber or dendrite, and negative at the output fiber, or axon. We realized that this electrical polarization might be what guided the impulses to move in one direction only, giving coherence to the nervous system.

As the year pushed on and moved into winter, they suddenly began to get abnormal results from the frogs they were experimenting on despite them not hibernating, eating and sleeping normally, and the lab being kept at the same temperature year-round. The frogs' voltage readings were lower, they stayed under longer at the same dosages for the anesthesia testing, and their blood vessels were more fragile, as if their bodies knew it was winter. Becker found a theoretical explanation for this, which was already being explored by Brown, a biologist at Northwestern University. Brown studied biological cycles, wavelike changes in functions such as sleep and wakefulness, and claimed that the rhythms of the earth's magnetic field served as a sort of metronome to the rhythms of life. Becker's DC system theory was able to provide a link by through which Brown's theory could occur.

Becker was able to further substantiate his theory that the current in the nerves were semi-conducting through experiments with temperature. If currents were carried by ions, the voltage would drop to zero if the section of the nerves were frozen. If the charge carriers were electrons in a semi-conducting lattice, then the voltage would rise as their mobility would be enhanced by freezing. Through repeated tests the semiconducting theory was proven repeatedly. Becker was able to publish his findings in the highly regarded British journal, *Nature*, and even received reprints. However, each step of the way there was substantial resistance from establishment scientists.

Through additional experiments with a strong electromagnet, Becker continued to prove the viability of an anesthesia which worked by counteracting the currents within the brain. This allowed animals to be revived and fully conscious within seconds of removing the electromagnetic field. In 1963 Becker spoke at the International Congress of Zoology, a great honor as this is not a yearly conference but only happens when there is enough scientific progress to warrant a meeting. There had only been 16 conferences since the first one in 1889. While his results were astounding and widely reproducible, his requests for further funding on exploring electromagnetic anesthesia on humans was ignored.

Chapter 6: The Ticklish Gene

In this chapter Dr. Becker demonstrates his credentials as an orthopedic specialist, which means focused on skeletal system and bones. Many think bones are dull, just architecture for more interesting mechanisms in the body. On page 119 he explained:

> Bone is extraordinary in structure, too. It's stronger than cast iron in resisting compression but, if killed by X rays or by cutting off its blood

> supply (barely adequate to start with), it collapses into mush. The part that's actually live, the bone cells, comprises less than 20 percent of the whole. The rest, the matrix, isn't just homogeneous concrete, either. It's composed of two dissimilar materials — collagen, a long-chain, fibrous protein that's the main structural material of the entire body, and apatite, a crystalline mineral that's mainly calcium phosphate. The electron microscope shows that the association between collagen and apatite is highly ordered, right down to the molecular level. The collagen fibers have raised transverse bands that divide them into regular segments. The apatite crystals, just the right size to fit snugly between these bands, are deposited like scales around the fibers.

Becker clarified that in addition to the remarkable properties of bone described above, the most important tissue to healing fractures is the bone marrow. This is where the cells are capable of dedifferentiation which forms the blastema, which fill the fracture and turn into cartilage cells etc. necessary to repair the fracture. This is true regeneration, and follows the same sequence of cell changes as what is found in salamanders when they regrow their entire limb.

Additionally, bone has the unique growth process called Wolff's law which states that a bone responds to stress by growing into whatever shape best meets the demands its owner makes of it. So when a bone is bent too long in one side, it adds more bone to support the additional strain. From this understanding of Wolff's law, Becker's team developed the theory that bone itself was piezoelectric. This theory was proven through repeated experiments in bending bones, finding that the stretched side created a positive potential and the compressed side created a negative potential. After publication, Becker did find that Japanese scientists Yasuda and Fukada had proven bones were piezoelectric in the 1950s.

Using this new information, Becker's team tested if bone growth could be induced by applying negative current to the bone marrow of living bones. It could. Becker's team was stimulating the DC control system of regenerative fracture healing, a technique that has been adopted successfully in healing nonunion fractures repeatedly in humans.

The idea that a semiconductive lattice containing "holes" can work with semiconductors containing excess free electrons was defined as a PN junction and it was concurrently being explored in the late 1960s in the field of solid-state devices. A current moving through it in a forward bias has some of its energy turned into light and emitted from the surface, it glows. This type of PN junction is now called a light-emitting diode (LED) and are everywhere in technology. Becker and his team was able to show that bone was an LED, emitting infrared frequency invisible to us, but it is an undeniable and consistent effect.

With this in mind, they tested the fluorescence of bone. It fluoresced with a blueish ivory color, despite the fact that collagen was typically blue and apatite was usually a brick-red. Their experiments produced more questions, as usual for good experiments, and they set out to explain why the fluorescence was not as expected. At the time solid-state technology had a new development called doping, where tiny amounts of certain minerals mixed into the semiconductor would change its properties enormously. Becker knew that certain trace metals bonded readily to bone: copper, lead, silver, and beryllium. Only copper gave an electron resonance of its own. Through a series of experiments Becker's team discovered on page 133:

> By analyzing it we deduced that each atom of copper fit into a little pit, surrounded by a particular pattern of electric charges, on the surface of apatite crystals and collagen fibers. Because the pattern of charges was the same in both materials, we knew that the bonding sites were the same on

> both surfaces and that they lined up to form one elongated cavity connecting the crystal and fiber. In other words, the two bonding sites matched, forming an enclosed space into which two atoms of copper nestled. The electrical forces of this copper bond held the crystals and fibers together much as wooden pegs fastened the pieces of antique furniture to each other. Furthermore, the electrical nature of peg and hole suggested that we had found, on the atomic level, the exact location of the PN junction.
>
> This discovery may have some medical importance. The question of how the innermost apatite crystals fasten onto collagen had eluded orthopedists until then, and the finding may have opened a way to understand osteoporosis, a condition in which the apatite crystals fall off and the bone degenerates.

Unfortunately, this copper-peg discovery has not been followed up on, despite being published in prestigious journals. Becker's team chose to focus on regenerative growth control, and there was no follow up from the greater scientific community on this leap in understanding of osteoporosis.

Ch. 7: Good News for Mammals

The first time artificial regrowth was created in a non-regenerating animal using electricity applied to the limb was by Smith at the University of Kentucky in 1967. Becker and his team followed up on this research on frogs with their own study on rats. They were able to produce remarkable results, with rats regrowing much of the bone shaft, with perfectly normal anatomical structures muscles, blood vessels, and nerves. Behind one of the artificially induced blastemas they even found a five-fingered shape as the rat began to regrow its hand as well. Becker explains on page 154:

> When we published our results, it was hard to shroud our excitement in the circumspect scientific jargon needed. We wrote that we'd activated true, though partial, regeneration with a minuscule direct current and that the marrow cells seemed to be the source of the blastema. I thought this claim was sober enough. Joe and I cautioned that other factors had yet to be studied. Most important, we warned that if such a tiny force could so easily switch on growth, it must be very powerful, and we'd best know it thoroughly before using it routinely on humans, lest we give them unwelcome growths—tumors.

Becker was asked to present his results to the New York Academy of Medicine, under the stipulation that two additional experts visit his lab to confirm the results. This was still a touchy battleground of the two philosophies of medicine: vitalism and mechanism. The possibility of electric growth control seemed a vitalistic flight of fancy to much of the established scientific community who were dedicated to mechanism. Scientists reproducing Becker's results also found that young rats were able to regenerate with similar results, meaning that this initial discovery of Becker's wasn't creating regenerative ability but rather extending the age of regenerative abilities in rats.

In the early 1970s in Sheffield Children's Hospital in England, there was a child who's fingertip had been amputated. In a clerical error, the attending physician dressed the wound and the

customary referral to the surgeon for the standard treatment (smoothing exposed bone and stitching skin closed) was never made. The child's fingertip grew back perfectly, without the less-than-optimal results that the standard treatment create such as nail deformed or missing, fingers too short, and diminished or absent sense of touch. By 1974, the doctor who discovered that case found several hundred cases of similar "neglect" where young children's fingers grew back perfectly as long as the amputation occurred above the crease of the outermost joint.

So, regeneration is still a possibility in mammals if they are still very young. Typically, it was believed that all powers of regeneration except fracture healing were lost to adult mammals. With this framework in mind, Becker's team made an additional remarkable discovery. Through an accidentally sloppy stitching, one of the experiments sutured the nerve to the skin of the injury. This created a neuroepidermal junction, a condition that is a requirement for normal regeneration of salamander limbs. This rat was able to partially regenerate its femur. They adjusted their experiments to further explore this occurrence, and found that even old rats were able to regenerate their thighbones and much of the surrounding tissue. Becker's team had discovered that the specific electrical activity that started regeneration was produced by the neuroepidermal junction. This junction occurred at the end of the stump, which meant that the blastema cells appeared exactly where they were needed to create a regeneration of the tip of the limb.

This work provided more strings for Becker's team to follow. As he explained on page 160:

> In mammals, it seemed, such cells were found only in the bone marrow, a sparse cell population to serve as a source of raw material, especially in adult animals.
>
> This explained why we never got complete regrowth in any of our rats. The results were typical of an inadequate blastema. There weren't enough sensitive cells in the bone marrow to make a blastema big enough to produce a whole leg. The prospects for full limb regeneration in humans, then, looked very dim—unless we could come up with a way of making other cells electrically sensitive so as to transform them into despecialized blastema cells. Luckily, while working on a completely different problem described in the following chapter, we stumbled upon a way to do just that.

Way to end the chapter on a cliff hanger, Dr. Becker!

Chapter 8: The Silver Wand

In 1970 at the University of Pennsylvania Friendenberg and Brighton reported the first successful electrical healing of a nonunion in a human. Becker began his own attempts at this in 1972, with a patient named Jim who broke both legs in a car crash. Initial treatment had put pins through skin and bone to hold the pieces together, but they had to be removed due to infection. The doctors could not perform an operation due to the bacteria, so they put him in a full body cast. Months passed, and not much progress was made in healing either the fractures in his legs or the infection.

By the time he reached Becker he had been bedridden in casts for months. Becker was cautious as with any experimental healing there may be side effects down the line that are unknown. He explained the risks to the patient Jim, who emotionally agreed to the experimental treatment as he was unable to face the possibility of life without his legs. Dr. Becker implanted silver electrodes, silver as it has known antibiotic properties. Within weeks the fracture began healing, and Jim was put in a walking cast and able to leave the hospital for the first time in sixteen months.

Becker's team began to do more experiments with silver and other metals. They found that it was the ions of silver and to a lesser extent gold that were able to kill resistant bacteria. A problem in the technique was that it was too localized to a quarter inch away from the wire. The team was able to find a remarkable solution that had previously been developed by NASA: an electrically conductive fabric which was a nylon parachute cloth coated with silver. This could be cut to any size and was very flexible.

By 1976 Dr. Becker had another extreme case, a man named John had been in a snow mobile accident, and during the initial treatment the broken bones had become infected. John had been fighting for three years, undergoing several operations to remove dead infected bone and the bacteria continued to spread. By the time he reached Dr. Becker the fractures had still not healed and he also had a long cavity in front of his shin which made the dead and infected bone visible. Becker's team found that John had a whole zoo of bacteria, five different kinds, and he agreed to the experimental procedure after being told of possible risks. Becker's team applied the silver nylon dressing to the wound after excavating dead and grossly infected tissue from his knee to his ankle. Within a week, all five kinds of bacteria had been killed. Within two weeks, the whole wound which had previously been over eight square inches of exposed bone was healing enough to begin growing skin. At that point Becker took an X ray and discovered that there was even bone growth, John's fractures were finally healing.

Silver was known to have healing properties since ancient times. Becker's team was able to prove that it stimulates bone-forming cells, cures infections against all types of bacteria, and stimulates healing in soft tissues. Just before their research group was disbanded, they were studying how electrically injected silver suspended the runaway mitosis in malignant cancer. Most important to Becker's theories was the knowledge that these silver techniques make it possible to produce large numbers of dedifferentiated cells, a possible way to overcome the main problem of mammalian regeneration the limited number of bone marrow cells that dedifferentiate in response to electrical current. The electrically generated silver ion can produce enough cells for human blastemas, leading to a viable possibility that limbs and other body parts can be regenerated in humans.

Becker points out that this field of research is very new and there are a lot of questions which urgently need research by electrochemists, but that work isn't being done. The research sponsors just aren't there despite these remarkable results.

Chapter 9: The Organ Tree

This chapter provides a survey of regenerative research done during Becker's career. Ultimately, he explains, all we learn about regeneration relates to a general system of communication among cells. This communication system includes the gene-protein enzyme system subsystems which govern specialization of cells to coordinate their chemical trade routes into well working tissues and organs. But the communication system clearly involves more, because chemical reactions cannot account for structure. Molecular dynamics, the mechanists' favored paradigm, cannot explain anatomy. On page 182 Becker explains:

> The DNA-RNA apparatus isn't the whole secret of life, but a sort of computer program by which the real secret, the control system, expresses its pattern in terms of living cells.
>
> This pattern is part of what many people mean by the soul, which so many philosophies have tried to explicate. However, most of the proposed answers haven't been connected with the physical world of biology in a way that offered a toehold for experiment.

I want to take a moment here to bring up another passage from earlier in the book, that provides the historical context for such a claim. Becker refers to research done before WWII on page 83:

> Burr and Lund advanced similar theories of an electrodynamic field, called by Burr the field of life or L-field, which held the shape of an organism just as a mold determines the shape of a gelatin dessert. "When we meet a friend we have not seen for six months there is not one molecule in his face which was there when we last saw him," Burr wrote. "But, thanks to his controlling L-field, the new molecules have fallen into the old, familiar pattern and we can recognize his face."

Becker reiterates that we can infer two things about the control for the regeneration process: as the blastema forms the right structure in relation to the whole organism then the guidance for the control process cannot be purely local as it pervades the whole body. Additionally, there are no extra blastema cells created, so there must be a feedback mechanism between the redifferentiation controls on the body side of the blastema and dedifferentiation stimulus at its outer edge. The polarity, magnitude, and voltage of the current provides a vector system for giving distinct values for every area of the body. Here is a list of the areas where healing has been restored by stimulating regeneration, and where more research is badly needed:

- Cartilage: Becker's team successfully healed rabbits of their arthritis using both silver implants and electrical injection of pure gold.
- Skull bones: Polezhaev was able to induce regeneration of holes in the skull using a paste of blood and living powdered bone, which was successfully accomplished in humans.
- Eyes: Newts can completely regenerate their eyes, and despite an enormous amount of research there is no explanation as to why they are unique in this. Becker points out that no one has studied its electrical properties.
- Muscle: Muscle regeneration has been successfully enhanced by inserting muscle tissue minced to pieces of no more than 1 cubic millimeter. This has been successful in humans replacing defective small muscles.
- Abdominal organs: In 1979, Becker's friend Dumont, a professor of surgery at NYU-Bellevue found that the cut intestines of rats healed better than with surgery if he just left the two loose ends in the abdomen. Here, like in the small children who had their fingertips shorn off, the sutures from surgery actually interfered with regeneration and produced unnecessary scars and adhesions.

Chapter 10: The Lazarus Heart

This was the shortest chapter in the book and describes a remarkable discovery. There is a standard method to harvest blood from a newt, which is fatal for the newt as it is so small that to get blood from it one must cut its heart in two. One of his team asked what might happen if they sewed the animals back up, to which Becker responded they would die, of course, their hearts had been destroyed. The next week when she brought the animals for the experiment and asked if they seemed healthy enough to test, he said yes. She replied that they were the same ones they had used the week before. Becker was flabbergasted and found upon dissection that their hearts were perfectly healthy with no evidence of ever being damaged in any way.

Becker abruptly pivoted his research plan to further analyze this phenomenon. Over 90% of these newts were able to survive the first operation wherein their hearts were cut in two. The results were challenging to analyze because even one day after the operation these newts showed only normal tissue with no sign of injury or mutilation.

They began to study the movement of the blood to better understand what was happening. This showed that motion stopped when the hearts were cut in two, but after about four hours it restarted! The blastema began to form in about two and a half hours. This was much faster than blastema development in the rest of Becker's research, and that is because it arose from a different process. This blastema grew from the nearest red blood cells which cracked open and the nuclei rush to the frayed edge of the heart muscle, guided by an unknown process. The parallel Becker drew was that it was as bizarre as if the engine of a passing car could walk up to a stranded truck, climb under the hood, and drive away.

Why did Becker's team discover this when others only found tiny, slow healing response from the heart? This was a manifestation of Polezhaev's principle: only massive damage unleashed the full power of the cells. In newts this level of "superregeneration" doesn't appear unless 30-50% of the heart is gone, there is something about the massiveness of the injury that boosts the healing process into overdrive. These results were published in the Nature journal, and have been corroborated by many. However, most biologists still don't accept heart restoration as a fact because it sounds so much like science fiction.

Chapter 11: The Self-Mending Net

In this chapter Becker looks towards the human central nervous system, which has no known regenerative capacity at all. However, he claims there is hope that we'll soon be able to coax nerve cells into reestablishing damaged connections and return sensation and function to quadriplegics and paraplegics.

Becker outlines the anatomy of the nervous system, drawing attention to the perineural cells which were previously thought to be just packing tissue. Through his research he's found that these cells play an important role in nutrient delivery to neurons, as well as helping to control the impulse firing of the nerve cells.

He also discusses the peripheral nerves, which in salamanders have very efficient regeneration capabilities. He theorizes that this is because it has a more efficient DC electrical system. He explains at the bottom of page 206:

> If the locator signal is electrical, it should be possible to augment it in humans so as to grow nerve fibers over longer distances. Beginning with a 1974 report from David H. Wilson of the Leeds General Infirmary in England, there have been some interesting claims that pulsed electromagnetic fields have speeded recovery of limb function in rats after peripheral nerve damage, but the effect hasn't yet been substantiated for humans. If these findings hold up, we may soon be able to boost nerves past their 1-centimeter limit, even if the action is indirect, and a thorough investigation of the electrical basics could drive nerve regrowth to even greater lengths.

Next, he tackles the spinal cord itself. While it is true that the spinal cord doesn't reconnect over even a fraction of a centimeter, the neurons below the injury didn't die. In most cases relatively few neurons die, so the reflex arcs remain intact. Often the reflexes are stronger than normal because the neurons are now disconnected from the brain which previously regulated them.

Consider this: the bones of paraplegics heal in half the normal time, whereas if the peripheral nerve is cut it is likely to not heal at all.

Salamanders can regenerate their spinal cord, but mammals cannot. This is because cysts and scar tissue form which do not allow the nerve fibers to penetrate the scar. This is possibly due to the spinal cords immediate response to the injury. At first even the simplest reflexes disappear, but as the shock wears off the cord below the injury becomes hyperactive. In young salamanders the shock only lasts a few minutes, but in mammals it takes as long as six months. Measuring the electricity of the spines of salamanders showed that they turned strongly positive during spinal shock even though all direct current flow stopped in the entire cord. As they recovered from the shock, the potential became increasingly negative. It seems a few minutes of shock and positive potential led to the full repair of the spinal cord, longer delays created incomplete regeneration. When the shock and positive potential lasted for longer than five days even the salamanders were completely paraplegic.

Finally, Becker addresses the brain. Salamanders, fish, and frogs can regenerate large parts of their brains. There is a form of shock called the spreading depression of Leão which occurs after brain injuries which starts at the site of the damage and spreads in all directions until the neurons shut down and the entire cortex is electrically positive. Studying this phenomena could be a way to open the possibility of self-repair for the human brain as well.

Chapter 12: Righting a Wrong Turn

In this chapter Dr. Becker explores the links between the regeneration process and possible cancer treatments. He identifies the three basic criteria to diagnose cancer. First, the disease arises from formerly normal cells of the host's body. Second, is uncontrolled growth rate and uncontrolled structural arrangement of the growing cells. The third is metabolic priority, which sees the diseased tissue taking all nutrients it wants first with the healthy part of the body getting what is leftover. There is an interesting observation to be made in that except for the lack of control, all three characteristics (cell simplicity, mitotic speed, and metabolic priority) are the hallmarks of embryonic growth and regeneration. Indeed, when embryos were implanted in the body tissue of a frog where they weren't rejected as expected they turned into highly malignant metastasizing tumors. It seems cancer arises when a normal cell becomes cancerous by dedifferentiation.

In general, when moving up the evolutionary ladder regeneration becomes less feasible, and cancer incidences increase. There seems to be a link there. When cancer cells were implanted into salamanders, then the cancerous limb was amputated through the cancer, the cancer cells re-differentiated along with the blastema as the limb regenerated. So, the regeneration guidance systems can control cancer as well, implying that cancer wasn't special but merely embryonic cells in a post-embryonic body.

This was heavily resisted by established medical scientists, as the widely held assumption was that carcinogenesis and differentiation was irreversible and the only possible way to cure cancer was to cut it out or kill it with drugs and radiation. These treatments generate modest increases in survival rates but damage normal cells as well. Becker lists a few colleagues who wanted to study the regeneration-cancer link but even just submitting a proposal for this type of research led to not only the proposal being rejected but the scientist being pushed out of their institution. The idea cannot even be considered according to the establishment, yet alone funded.

As stimulus and control of the nerves is necessary for regeneration to occur, it is logical to conclude that these also exert some controlling effect on cancer. They do. As far back as the 1920s there were several experiments implanting cancer into denervated areas and without exception the cancer grew faster than where the nerves were intact. The absence of nerves accelerates tumor growth. In 1927, a student of Jung named Evans documented a link between depression and cancer

which was confirmed repeatedly in later studies. This adds to abundant evidence that the entire nervous system can affect cancer.

There has been a number of studies on how to greatly increase cancer patients' survival chances with visualization and meditation techniques, such as imagining white blood cells as knights on white horses defeating an army of marauders. One study employing this visualization method found the cancer had completely regressed in 22% and was receding in an additional 19%. Those who did eventually die from their cancer lived twice as long as originally diagnosed before the treatment.

Becker references one study from the 1950s by Humphrey and Seal at Johns Hopkins in which pulsed direct currents on skin tumors in mice resulting in total remission in 60% of the test animals after only three weeks. There is still a lot of risk in the area, as some studies find both positive and negative currents can also speed up tumor growth by 300%. In some of his research Becker shows that using a silver ion injection with a small positive current seems to help cancer cells dedifferentiate completely and stop dividing and growing even a month after treatment. There is also promising research suggesting that strong magnetic fields can stop mitosis in malignant cancerous cells.

But of course, the scientific community needs to be open minded enough to accept these research proposals and provide funding to do the necessary research into these methods. Even non-electromagnetic approaches are heavily biased against in cancer research, for example the lack of follow up on the evidence that large doses of vitamin C slows tumor growth. Becker concludes that while the multi-billion dollar cancer research bureaucracy can afford it, but the establishment paradigm of the fight against cancer as a surgical, chemical, and radioactive war prevents any serious consideration of alternative treatments no matter how much evidence there is to support it.

Chapter 13: The Missing Chapter

While in medical school in the 1940s, Becker recalls, a rigorous professor would constantly remind them that surgeons could cut, rearrange or remove tissue, and sew a wound up, but it was only the patient who does the actual healing and they must be humble before this miracle. Becker laments that only through fragmentation of the body can students deal with the complexity that otherwise would overwhelm. This is an excellent strategy for engineering, but it is a reductionist assumption that once you understand the parts you understand the whole. That approach fails in the study of living things. Life is more than the sum of its parts. And life does not tolerate being fragmented very well. It is modern arrogance to assume that we do not need to understand the complete picture of how the body functions, including the possibilities in the blind spot of dogmatic science. Perhaps both the mechanists and the vitalists were at least partly right, and science has done itself a disservice by so rigorously ignoring the evidence. On page 232 he explains:

> When I entered research, I aimed for a fairly limited goal among the many that lured me—finding out what stimulated and controlled the growth needed for healing—but always in the back of my mind were the larger questions that had haunted me since medical school: What unified an organism, making every cell subservient to the needs of the whole? How was it that the whole being could do things that none of its components could do separately? What made an organism self-contained, self-directed, self-repairing? When you get right down to it, I wanted to know what made living things alive. Intuitively I felt sure the answers needn't be forever hidden in mystic conundrums but were scientifically knowable. However, they would

> require a fresh approach from science, not the simple mechanistic dogmas left over from last century. As a result of the research on nerves and regeneration described in the foregoing pages, I believe I can now sketch at least an outline of that missing chapter.

In 1971, Becker was able to participate in research around the effectiveness of acupuncture as a pain blocker. He suggested that there were electrical conductors that carried an injury message to the brain, which responded by sending back the appropriate level of direct current to stimulate healing. These electrical conductors could very well be the acupuncture meridians. He proposed that the brain receiving that input included a message to the conscious mind that we interpreted as pain. If you block the incoming signal, you would prevent the pain. Becker suggested that acupuncture did exactly that.

One of Becker's colleagues, a psychiatrist Friedman, had been using hypnosis to control chronic pain in his patients. Becker reluctantly admitted that he originally doubted this, like many others, thinking hypnoanalgesia was a state in which the patient still felt the pain but didn't respond to it, but the experiments proved it was a real blockage of pain perception. Becker explained that the brain can shut off pain by altering the direct-current potentials of the body. It was likely that pain control through biofeedback or yoga etc. works by using the circuit for modulating the pain signal which releases endorphins. Becker believes that research on this could continue until we learn how to control pain, healing and growth with our minds alone, substantially reducing the need for physicians. He explains on page 242:

> Thus our bodies have an intricate and multilayered self-regulating feedback arrangement. We know, on the psychological level, that a person's emotions affect the efficiency of healing and the level of pain, and there's every reason to believe that emotions, on the physiological level, have their effect by modulating the current that directly controls pain and healing.

Chapter 14: Breathing with the Earth

In this chapter, Becker takes time to link his biology experiments with theories on how they might change our understanding of earth. After all, over and over again biology has found that the whole is more than the sum of its parts, and we can expect the same is true of bioelectromagnetic fields. This view would consider all life on earth as a unit, connected within a vaster electromagnetic field, with direct influences from heavenly bodies such as the moon and the sun.

These revelations began for him when he volunteered in the Aurora Watch Program in the 1950s. He went through the data to see if there was any correlation between disturbances in earth's field caused by magnetic storms on the sun, and psychiatric disturbances. As it turned out, there was. Nurses reported various behavior changes corresponding to the solar storms, with a lag of one or two days later when those cosmic rays from the sun were known to produce strong disturbances with the earth's field.

Additional experiments showed that humans had slowed reaction times and rabbits had stress responses when exposed to fields ten to twenty times the normal strength of the earth's. The circadian rhythm of metabolic activity, assumed to be linked to the alterations of night and day or the tides, but were proven to be linked to the earth's magnetic field. The earth's magnetic field varies as the moon revolves around it as well. The potential interactions among all of these electromagnetic phenomena and life are infinitely complex.

Through a series of experiments on increasingly complex creatures, starting with fruit flies and ending with humans in underground rooms isolated from all clues to the passage of time, proved the connection between electromagnetic fields and circadian rhythms. The people in the rooms that were still exposed to earth's field kept up a 24 hour rhythm, even as they lost track of time. Those in rooms which were shielded from earth's field became thoroughly desynchronized.

This relationship has been conclusively proven by studies on the pineal gland, the "third eye" of mystics. It produces melatonin and serotonin which controls all biocycles. Becker explains on page 249:

> For our story the most important point is that very small magnetic fields influence the pineal gland. Several research groups have shown that applying a magnetic field of half a gauss or less, oriented so as to add to or subtract from the earth's normal field, will increase or decrease production of pineal melatonin and serotonin. Other groups have observed physical changes in the gland's cells in response to such fields. The experiments were controlled for illumination, since it has been known for several years that shining a light on the head somehow modifies the gland's hormone output even though it's buried so deeply within the head in most vertebrates that, as far as we know, it can't react directly to the light.
>
> We likely have yet to discover many other ways that energy cycles in the solar system affect life on earth. They may strongly affect the outbreak of disease, for example. The last six peaks of the eleven-year sunspot cycle have coincided with major flu epidemics. A Soviet group under Yu. N. Achkasova at the Crimean Medical Institute, working with astronomer B. M. Vladimirskiy of the Crimean Observatory, has found a connection between the sun's magnetic field and the Escherichia coli bacteria that live in our intestines and help us digest our food. The Russians found the bacteria grew faster when the sun's field was positive, or pointing toward earth, and slowed down when it was negative. Two days after the passage of each sector boundary there was a dip in bacterial growth corresponding to the maximum geomagnetic turbulence. The data also showed a decline in growth in response to large solar flares. Other Russian scientists have drawn a tentative correlation between the sector cycle and reports from two groups of persons with neurological diseases. The patients felt worse within sectors of positive polarity, when bacteria seemed to grow faster. Life's geomagnetic coupling to heaven and earth is apparently more like a web than a simple cord and socket.

Out of curiosity, I looked up the solar cycles from the last 20 years and noticed that increasing sunspot cycle peaks correlated to virus outbreaks like SARS in 2002 and the Ebola outbreak that even reached the US in 2014. We are currently in solar cycle 25 which began in 2020, which is quite a coincidence considering the pandemic that occurred. Correlation is not causation, but as a continuation of Becker's writing in 1985 his theories hold up very well even 40 years later.

Back to the Body Electric, Becker covers literature of experiments which explored how bacterium had magnetic crystals, with further research finding similar crystals in bees, fish, pigeons, and up to 27 other types of organisms, including several primates. Becker suggests that a magnetic sense has existed from the very beginning of life. Similar magnetic deposits have been found in the

sinuses of humans, in the center of the head behind the nose between the eyes. This puts them very close to the pineal and pituitary glands.

Becker then proposes an interesting alternative to the usual biological soup origins of life. Becker explains on page 257:

> The criteria for life can be summarized as organization, information processing, regeneration, and rhythm.
>
> The funny thing is that all of these criteria are met by the activities of semiconducting crystals. Semiconductivity occurs naturally in several inorganic crystals, including silicon, one of the most common elements, and the rare earth germanium. Moreover, extremely small amounts of contaminants will change the crystal's electrical properties dramatically in doping. The earth's volcanic mixing would have produced minerals with a wide variety of current-handling abilities to start from. Most important, the piezoelectric, pyroelectric, photoelectric, and other responses of semiconducting crystals could have served as an analog method of processing and storing information about pressure, heat, and light….
>
> Movement of electrons along the crystal lattices inevitably would have been shaped by geocelestial cycles in the earth's electromagnetic field, as well as by the fields around other such crystalline organisms nearby—providing a sense of time and information about the neighbors. The currents also would have instantly reflected any loss of material and guided the deposition of replacement atoms to restore the original structure….
>
> The idea of certain rocks, in the course of a billion years or so, gradually becoming responsive to their surroundings, growing, learning to "hurt" when a lava flow or sulfuric rain ate away part of a vertex, slowly rebuilding, pulsing with, well, life, even developing to a liquid crystal stage and climbing free of their stony nests like Cadmus' dragon's teeth or the lizards in an M. C. Escher print—all this may seem a bit bizarre. Yet it's really no more strange than imagining the same transformation from droplets of broth. The change happened somehow.

With all of these magnetic functions of life, Becker then dives into the historical evidence of the earth's magnetic poles shifting and how these cycles seem to correspond to mass extinctions and provides research supporting the idea that there may be some solar or galactic influence that interacts with a magnetic reversal for maximum destructive effect. While pole shifts happen so slowly that life could adapt to it, if a geomagnetic reversal raises the micropulsation frequencies into a certain range, the accumulation of growth errors over many generations could well mean extinction. Becker explains that several scientists from NASA found evidence that the earth's magnetic field strength is steadily declining, and has been for the last few thousand years. If so, we may already be entering the next reversal, and while humans have weathered these before in the past this will be the first time in which the normal field is contaminated with our own electromagnetic effluvia from our recent technology advances.

This seems frightening, but some researchers have proposed a direct link from these magnetic fields through the growth-hormone regulator pathways in the brain which account for sharp evolutionary gains. The hippocampus, which could act as a transducer of electromagnetic energy, is much larger in humans than in other primates. A historical survey of brain sizes of ancient humans showed that there were huge bursts in brain size evolution which corresponded to the

major ice ages as well as major advancements in cultural achievements such as mastering fire. These time periods also corresponded to higher average geomagnetic field intensity. It could be that this subtle force which is completely invisible to us is the most powerful shaper of our development.

In this chapter, Becker also introduces us to how this body of evidence also supports the possibility of parapsychic phenomena. If one nervous system could sense the electromagnetic field of another, then it would go a long way toward explaining extrasensory perception. Keeping in mind this was published in 1985, Becker explained on page 266-269:

> There's now some evidence that psychic intent can influence the flow of current in solid-state devices, so we may be nearing the energy levels at which extrasensory factors work. Since all living things generate weak electromagnetic fields, and since many, if not all, can sense those of the earth, communication by this medium remains a strong possibility. Recent disclosure of a multimillion-dollar research effort in this area by the hardheaded weapons planners at the Department of Defense is one more reason why those scientists who work in public shouldn't dismiss the idea….
>
> The biofield also lends itself to theories of psychokinesis and object imprinting. All matter, living and nonliving, is ultimately an electromagnetic phenomenon. The material world, at least as far as physics has penetrated, is an atomic structure held together by electromagnetic forces. If some people can detect fields from other organisms, why shouldn't some people be able to affect other beings by means of their linked fields? Since the cellular functions of our bodies are controlled by our own DC fields, there's reason to believe that gifted healers generate supportive electromagnetic effects, which they convey to their patients to manipulate to change the sufferer's internal currents directly, without limiting themselves to the placebo effect of trust and hope.
>
> Once we admit the idea of this kind of influence, then the same kind of willed action of biofields on the electromagnetic structure of inanimate matter becomes a possibility. This encompasses all forms of psychokinesis, [including] metal-bending experiments.

So, here Dr. Becker provides a theoretical explanation, based on a solid foundation of a lifetime of medical research, on how there is no spoon.

Chapter 15: Maxwell's Silver Hammer

After illustrating the profound effect on life that the earth's electromagnetic field has, Becker states it is the responsibility of science to present dangers as specifically as possible and points to a question he calls obvious: What are the consequences of our artificial energies?

Electromagnetism can be discussed in terms of fields and in terms of radiation. Both electric and magnetic fields are unvarying, and over time and by varying the intensity of the field like in a radio antenna, the electromagnetic field is created. The fluctuations in this field radiate outward as waves of energy moving away from the transmitter. This electromagnetic field (EMF) is sometimes called electromagnetic radiation (EMR) to emphasize the outward flowing aspect. These terms are interchangeable.

For billions of years the energies that life grew around were relatively simple. We will never know that quiet world again. Edison set up the first commercial electric-power system in New York

in 1882, Tesla lit the Chicago's World's Fair with the first AC power system in 1893 and two years later he harnessed the power of Niagara Falls to begin the modern era of electrical engineering. But Becker points out that the greatest changes have all come in the one generation since World War II. The use of shorter and shorter radio waves for long-distance communication, the development of the microwave radar, the first television broadcasts, among many others; we are all awash in a sea of energies life has never before experienced. As Becker explains on page 276:

> In a sense, the entire population of the world is willy-nilly the subject of a giant experiment. Electropollution has been the subject of heated *public* debate for nearly ten years, and unpublicized misgivings for decades before that. Unfortunately, the question of risk has been asked too late. Daily exposure of nearly everyone is a *fait accompli*.

Here I want to take a moment to again emphasize that Dr. Becker wrote this in 1985. That was also the year I was born, and in my entire well-read life I've never even heard of electropollution in the way he is describing. It seems like the generation before mine was aware of a risk enough to protest, weakly, and then the whole of the idea was fragmented into parts that we could argue over. Climate change, the changes in the clouds in the sky, the changes in our bodies so that we are weaker, the sicknesses that seem to be getting worse, these are all just symptoms of what Becker is discussing in this chapter. He is raising the alarm that these things were happening as early as 1985, and as I consider the past 40 years it is undeniable that his concerns were valid as things have gotten worse as technology has made revolutionary leaps and bounds. This is why I thought it was so important to write up these notes.

Back to the Electric Body, Becker goes on to describe how after his team found evidence that solar magnetic storms were affecting the human mind as reflected in psychiatric hospital admissions, they decided to do direct experiments on people. They were measuring the standard reaction times of volunteers whose brains were placed within the line of a magnetic field. The reaction times slowed dramatically even with low force, and Becker's team excitedly planned similar experiments until they came across a Russian report which had been running similar experiments and found that it was creating areas of cell death in the brains of the rabbits they were experimenting on.

When Becker's team examined the slides of this experiment, they found that all of the animals had been infected with a brain parasite that was unique to rabbits. However, in the control group the immune system had it under control. In the animals subjected to the magnetic field the immune system had quickly been defeated, it was discovered that the fields were causing a generalized stress reaction which released a large amount of cortisol into the bloodstream. Further studies have shown these EMFs triggered releases in adrenaline triggering fight-or-flight, as well as insulin insufficiency and a rise in blood sugar. The most concerning thing was that despite this happening chemically, in a way that was clearly seen in lab results, the animals did not act in distress at all. It was as if they were unaware it was happening, even though the stress response was clearly affecting their bodies. Becker noted that the fields in these experiments were within the levels found in a typical office with overhead lighting, computers, and other such equipment. Becker explains on page 278:

> Because industry and the military demand unrestricted use of electromagnetic fields and radiation, their intrinsic hazards are often compounded by secrecy and deceit.

Becker was part of a crusade in the 1970s, as he was researching the EMF-stress connection the Navy decided to build a giant antenna in northern Wisconsin. The plan was to be able to communicate with nuclear submarines at their normal depth using a transmitter which issue ELF waves anywhere between the earth's surface and the ionosphere that could be picked up anywhere on the globe. Becker argued that the research to date showed that similar fields had raised human risk of heart attack or stroke, as well as change the blood pressure and brain wave patterns in animals. There was risk of the generalized stress response which could interfere with cellular metabolism and growth processes which would increase cancer rates. Becker and others unanimously recommended that the project be shelved pending additional research into these concerns. They listed the necessary research to clarify the risks to these fields and also warned that the health of large parts of the U.S. population might have already been impaired by the powerlines which carried more power than the proposed antenna. The Navy was displeased with this, and classified the findings for official use only and then refused to discuss them with anyone else.

Shortly after, Becker learned that there were plans to run power lines through a village where he had just bought a retirement home. Becker didn't feel it was his place to release his report to the Navy, but he also felt that suppression was wrong. Instead, Becker summarized the major conclusions and testified on the hearings regarding these power lines. He reported how power line intensity had been linked to bone tumors in mice, slowed heartbeats in fish, and various chemical changes in the brains, blood, and livers of rats. Bees exposed to strong ELF fields began to sting each other to death, seal off their hives and asphyxiated themselves, or simply fled the area. Three generations of rats bred within these fields showed severely stunted growth, especially among males. Animals gained more weight than the controls, there were large increases in infant mortality rate, and the adrenal glands became enlarged consistent with stress. There were also very high incidences of glaucoma and other eye issues.

The power company hired two researchers who primarily worked for the Department of Defense who cross examined Becker's team for 17 days, attacking their methods, results, scientific competence, and honesty. They denied that the animals showed signs of stress, despite the obvious biological markers, and also contended that stress could be helpful. Becker did eventually win that battle, and the power lines did not go up in the community he testified on behalf of.

This was the first time American scientists were openly giving a testimony stating that electromagnetic energy had health effects and that power lines might be hazardous to human health. They criticized the White House for failing to follow up on a 1971 warning advising the President that some harmful effects from electropollution were now proven.

Becker explains some of the nuances to these studies. The extremely low frequencies are the most problematic, but higher frequencies can have the same effects if pulsed or moderated which is necessary to transmit information. Therefore, experiments in which cells or organisms are exposed to a single unmodulated frequency are irrelevant outside of the lab, yet these are what's done by researchers whose only goal is to say that there is no cause for alarm.

Becker then details the danger in the way these frequencies can affect other bodily functions:

- Central Nervous System: reaction speeds slow; short term memory deteriorates; damage to the hypothalamus and pituitary glands; lower dopamine levels; and exhausted adrenal cortex. Additionally, the blood-brain barrier is compromised and the mitochondria of the brain malfunction resulting in decreased brain energy levels. Becker notes that research points toward "confusion beam" weaponry as a viable possibility, but no research on that is open. Finally, in people living near power lines (even underground power lines) rates of depression and suicides are 22% higher than those not living near power lines.

- Endocrine, Metabolic, and Cardiovascular system: ominous changes in red and white blood cell counts and across-the-board decline in the immune response; thyroid disfunction; elimination of the normal nightly rise in production of pineal gland hormone melatonin; disruptions in the bloods sodium-potassium balance; and more. Just one day of exposure to a magnetic field such as from an ELF antenna caused a 50% raise in triglycerides in 9 of 10 humans. Heart attack rates in Finland became the highest and most swiftly increasing in the world within a few years after the Soviets installed a gigantic radar complex which bounced microwaves throughout Finland.
- Growth control systems and immune response: these fields can throw off the mitotic cycle time of every cell, interfering with growth processes in the body; they found evidence of a decline in the efficiency of white blood cells; and under ELF fields the concentration of bacteria needed to kill mice was only one fifth that needed without the field. There is evidence that only slightly increased electric fields stimulated the growth of all bacteria and increased resistance to antibiotics. Becker points out that the evidence is sketchy, because the research hasn't been thorough, but there is viable concern that we are developing weaker immune systems and stronger diseases. He points out several diseases which, while naturally occurring, are now posing a much greater problem for us: Lyme disease; Legionnaire's disease; and herpes. Even cancer rates have gone up tremendously: in the mid-60s about a quarter of the US population could expect to develop it, but by the mid-1970s that increased to a third of the population. Children raised underneath high current power lines have almost double the rate of childhood death from leukemia, lymph node cancer, and nervous system tumors.

Becker notes that there are many factors which could be contributing to these results, but that the results span the globe with the same rates even though chemical toxicity, eating habits, and styles of life are wildly divergent. Much of the research was done behind the Iron Curtain, which inclined the West to discredit it for political reasons. Becker notes on page 289 that "Western researchers have hamstrung themselves with the dogma that there simply can't be bioeffects from low levels of electromagnetic energy—so why bother looking?"

Becker describes the different standards considered safe between the East and the West, and how at a 1969 international symposium on microwaves Dr. Marha of Prague's Institute of Industrial Hygiene defended his findings on birth defects. There were objections that the dire predictions hadn't been proven beyond a doubt to which he responded: "Our standard is not only to prevent damage but to avoid discomfort in people."

This back and forth between the West claiming there was no effect, and the East claiming there were risks that needed to be considered went on throughout the Cold War. In 1952, after a secret meeting which was perhaps more contentious, the Soviets began beaming microwaves at the U.S. embassy always staying well within the Schwan limit safety standards that the Americans argued for. The Ambassador developed a rare blood disease similar to leukemia and suffered from headaches and bleeding from the eyes. Two others died of cancer.

Becker then goes on to describe all of the weaponized possibilities of this invisible electromagnetic warfare:

- Certain pulsed microwave beams increased the permeability of the blood-brain barrier which could enhance the effects of drugs, bacteria, or poisons.
- Certain pulsed microwaves could be heard by people, causing booming, hissing, or clicking from just behind the persons head causing pain and preventing all voice communication while also making the target crazy.

- Other pulse frequencies can cause pressure waves in tissues, a research group found that they could speed up, slow down, or stop frog's heartbeats, making it technically feasible to produce heart attacks with a ray weapon.
- Specific electric patterns could also completely control behavior. They were able to compel monkeys to follow specific activity orders, which they were able to do while avoiding threats from other monkey or obstacles in the cage.
    - They were even able to make these monkeys turn their heads and smile no matter what else they were doing. One observer concluded that "the animals looked like electronic toys."
- Even instincts and emotions can be changed: in one test at a signal a caring mother suddenly pushed her infant away.
- Becker points out that by design or not, the hypnotic nature of TV and radio combined with the biological effects of their broadcast beams may already constitute a similar force for mass standardization.
- Electromagnetic mind control was a large component of MK Ultra, even though the hypnosis and psychedelic drugs stole the show in the eye of the media.
- In the mid-1970s American researchers developed a plan to explore hypnosis-EMR interactions, which implanted hypnotic suggestions for simple acts which were triggered at certain times or by certain words. Afterwards the subjects were interviewed and they all rationalized their behavior and considered it taken of their own free will.
- Similar hypnosis-EMR experiments generated personality changes measurable by personality tests take a month apart. Some subjects were even programmed to become sleep talkers, which allowed the programmer to gear the commands towards thoughts that were already in the brain.
- In 1976, the Soviets started sending a new radio signal. This was called the woodpecker, and it corresponded with several people in Eugene, Oregon developing symptoms such as pressure or pain in the head, anxiety, fatigue, insomnia, lack of coordination, numbness, all with a high pitch ringing in the ears. These are characteristic symptoms of strong radio-frequency or microwave irradiation. Some theories are that the Eugene phenomenon might have been the interaction between a Navy broadcast from a nearby base and Soviet jamming.

Becker concedes that our civilization is irreversibly dependent on electronics, so abolition of EMR is out of the question. He suggests a first step towards averting disaster would be to pause the introduction of new sources of electromagnetic energy while we investigate the biohazards of those we already have with completeness and honesty. He insists that our survival depends on upright scientists to break the military-industrial death grip on our policy-making institutions. He also includes a passionate post-script regarding the politicization of science, and how funding is used as a cudgel to enforce dogmatic thought and silence new ideas.